Phase IV: Production and Deployment

Step 21.0 Prepare Equipment Installation Criteria

Objective:

- Installation criteria will be developed based on operator and maintainer access requirements, safety considerations, and task analysis results. Mockups and scale models of equipment installations will be developed to verify accessibility, operability and maintainability. Lessons learned from predecessor systems will be examined to identify problems with equipment installation.
- The engineering process for CG systems of the future must include a commitment to total quality in the installation of the system into its intended environment. Quality is a characteristic of a system which demands that the development process be efficient, that the system products be affordable, reliable, durable and usable, and that the system meets appropriate quality standards. A commitment to quality involves a dedication to ensuring that systems will be able to meet in the 21st century. Systems will meet quality standards to the extent that they are usable, durable, effective, affordable, and safe. The HF/S aspects of these systems is important to the extent that successful system operation depends on human performance, and that its quality depends on ease and safety of its use.

Inputs:

- Installation requirements and constraints

Outputs:

- Assessments of installations based on HF/S criteria

21.1 Identify equipment installation requirements

21.1.1 Identify Location Requirements

- Identify space layout for equipment installation
- Identify location constraints
- Identify alternate locations

21.1.2 Identify equipment configuration requirements

- Identify spatial configuration of the equipment in the space
- Identify the range of configurations
- Identify requirements for configuration changes
- Identify dimensions associated with each configuration

21.1.3 Identify operation & maintenance requirements

- Identify operations tasks to be conducted in the space
- Identify requirements associated with operations tasks to be conducted in the space with the equipment
- Identify requirements associated with operations tasks to be conducted in the space in proximity to the equipment
- Identify operational modes
- Identify free volume requirements associated with operations tasks
- Identify time constraints associated with operations tasks
- Identify operations conditions to include the following:
  - logistics conditions (length of supply lines, resupply frequency, capacity)
  - conditions of readiness (systems not operational, extent of damage, etc.)
  - environmental conditions (lighting and visibility, weather, temperature, etc.)
  - operational conditions - sustained operations, clothing conditions, etc.
- Identify maintenance tasks to be conducted in the space
- Identify requirements associated with maintenance tasks to be conducted in the space with the equipment
- Identify requirements associated with maintenance tasks to be conducted in the space in proximity to the equipment
- Identify maintenance modes
- Identify free volume requirements associated with maintenance tasks
- Identify time constraints associated with maintenance tasks
- Identify maintenance conditions to include the following:
  - logistics conditions (length of supply lines, resupply frequency, capacity)
  - conditions of readiness (systems not operational, extent of damage, etc.)
  - environmental conditions (lighting and visibility, weather, temperature, etc.)
  - operational conditions - sustained operations, clothing conditions, etc.
  - frequency of maintenance actions

21.1.4 Identify access/egress requirements - The objective of this effort is to identify access/ egress design requirements based on requirements and HF/S criteria.

- *Identify access/egress design specifications* - This activity is concerned with identifying criteria and design specifications already in place governing requirements for access/ egress use and design. Primary sources of data will include HF/S criteria from standards such as MIL-STD 1582D and design specifications and criteria for access/ egress from other sources. Data will be of two types: those governing the design dimensions and characteristics of access/egress provisions; and those governing the use and operation of these provisions.
- *Acquire data on existing and planned access/egress provisions*
  - Data on existing and planned access/egress provisions will be acquired from three classes of sources: design agents, test and evaluation data bases, and operational data sources. Design data to be collected will include design waivers and deviations as they pertain to access/egress provisions. Design data will also include dimensions and design characteristics of access/egress provisions as installed in existing facilities. Test and evaluation data will include reports on the adequacy of access/egress provisions from HF/S and safety evaluations of

existing provisions. Operational data will be acquired from: a) interviews with operational personnel, b) reports on critical incidents; and c) from HF/S inspections of existing implementations.

- *Prepare lessons learned for existing access/egress provisions*
  - Data acquired on access/egress provisions in existing and planned facilities will be analyzed to identify access/egress lessons learned. Lessons learned data are of three types:
    - 1) problems in the design and/or use of access/egress provisions;
    - 2) positive aspects of provisions; and
    - 3) deficiencies in existing standards and specifications, and in the extent to existing standards and specifications are met. Lessons learned data will be further analyzed to identify the causes for problems, deficiencies in design standards, and situations of non-compliance with standards. Problems and shortcomings will be prioritized in terms of impact on crew safety and survivability.

21.1.5 Identify facility/installation design requirements

- The single most important determiner of the design of a manned facility should be the requirements of the facility users, including personnel who will inhabit the facility and who will perform operations, maintenance and support functions within the facility. The end result is often a constructed facility which fails to meet important user requirements and needs but which cannot be modified without considerable additional costs. The ideal situation is to address user requirements and needs early in the design process where HF/S engineering considerations can influence facility design at a nominal cost. The steps to be pursued in the identification of facility requirements are as follows:
- *Identification of users*
  - The initial step is to identify facility users by user role. Specific roles include those of inhabiter, operator, maintainer, security guard, clerical worker, computer specialist, supervisor, and material handler. Requirements for performance of jobs will be identified including an identification of duties associated with each job. An estimate will also be made of the percentage of time that specific users, by role and/or job title, are housed within the facility.
- *Identification of facility uses and use conditions*
  - For each user and user role/job, facility uses will be identified. Uses of the facility include duties performed within specific areas of the facility. In addition, use conditions will be identified which will include those situations which will have an impact on the performance of assigned duties, such as emergency conditions, contingency conditions, conditions of high workload, tight time constrained situations, and conditions of workload.
- *Identification of user functions by use*
  - User functions will be identified for each duty, facility use and use condition.
- *Identify requirements by function*
- Requirements associated with specific functions by use conditions will be identified. Requirements will include:
  - Information requirements including information needed to perform the function, source of the information, and specific characteristics of this information

including update rate, accuracy and quality requirements.
    - Decision requirements including decisions, options, decision rules, feedback required and impact of an erroneous decision.
    - Performance requirements including tolerances on performance and specific capabilities required.
    - Support requirements including support required from within the facility system in performing each function.
    - Interface requirements including interfaces with other systems required for function performance.
- *Conduct user task analyses* - For each user function for each use and under each use condition, user tasks will be identified and analyzed. The task analysis will address such task descriptors as frequency and expected duration of tasks, information needed to perform the task and characteristics of the information, performance requirements associated with the task, decisions required in task performance, and factors associated with the facility design and environment which are expected to impact the safe and effective performance of the task. The task analysis will also identify specific user-equipment and user-facility interfaces associated with the performance of each task.
- Identify architectural/engineering (AE)constraints Architectural/engineering constraints include situations where the design of the user-machine and user-facility interfaces is constrained by structural, engineering or cost factors and where the HF/S engineering effort will have to comply with the constraints. These AE constraints will require approval of customer personnel.

21.1.6 *Identify safety & health requirements* - Identify safety and health requirements associated with the proposed installation and the resultant facility design. The process for identifying requirements will address:

- Review Pertinent Historical Safety Experience
- Categorize and List Basic Energy Sources
- Investigate Provisions for Control of Energy Sources
- Identify and evaluate safety related interface considerations among subsystems
- Identify and evaluate environmental constraints (Including operational environment)
- Identify and evaluate procedures
    - Operating
    - Test
    - Maintenance
    - Emergency
- Identify safety requirements and other regulations with which the installation will have to comply
    - Personnel safety
    - Environmental hazards
    - Toxic substances
- Identify Sources of safety & health hazards
- Determine routine or planned uses and releases of sources
- Determine toxicity, quantity, and physical state of materials
- Determine accidental exposure potential
- Identify Hazardous waste generated

- Determine personnel-hazardous material interface requirements
  - Handling
  - Transfer
  - Transportation
- Determine protective clothing/equipment needs
- Determine detection and measurement devices required to quantify exposure
- Determine number of personnel potentially at risk
- Determine engineering controls that could be used to reduce exposure/ exposure potential

21.1.7 *Identify environmental requirements* - Identify environmental requirements for each operations and maintenance task conducted with the installed equipment, to include:

- lighting
- maximum acceptable noise levels
- maximum acceptable vibration levels
- atmospheric composition
- maximum acceptable temperature levels

21.1.8 *Identify signs/labels/marking requirements* - The expected results to be attained from attending to sign, labeling & marking requirements include:

- reduction in time to read and understand signs, labels and markings
- reduction of errors associated with using signs, labels and markings
- reductions of accidents caused by misreading signs, labels and markings
- The steps to be followed in the identification of signs/label/marking requirements are described in the following sections.
  - Step 1: Classify signs/labels/marking applications and use conditions. The classification of sign, labeling and marking applications will attempt to develop a taxonomy of sign/label/marking objectives in an operational context. The classification of sign/label/marking use conditions will identify the range of environmental and operational conditions under which the sign/label/marking is to be seen, read and understood.
    - 1.1 Classify sign/labeling/marking applications
      - 1) Identification
        - System identification
        - Equipment identification
        - Compartment/passageway identification
        - Procedures identification
      - 2) Designation
        - Equipment status designation
        - Display screen designation
        - Route designation
        - Documentation designation
        - Control direction designation
        - Active element designation
        - Enclosing or grouping elements
      - 3) Orientation

        - Roadmaps
        - Arrangement maps
        - Subassembly orientation
        - System/subsystem orientation
      - 4) Instruction
        - Procedures
        - Warnings
        - Advisories
      - 5) Information
        - Status
        - Message
        - Refresh training
        - Component descriptions
        - System descriptions
      - 6) Alarm/alert
        - Annunciators
        - Legends
        - Auditory alarms
    - 1.2. Classify use conditions
      - Environmental conditions
      - Operational conditions
      - User clothing conditions
      - User stress conditions
- Step 2: Identify HF/S sign/labeling/marking issues. Sign, labeling and marking issues include the factors associated with the sign, label and marking itself, the message, the environment, and the reader, which have an impact on reader performance. Specific classes of issues include the following:
    - 2.1. Adequacy of the message (the 7 C's)
      - Completeness/comprehensiveness
      - Correctness
      - Conciseness/ clarity
      - Consistency
      - Currency
      - Compatibility with user skills
      - Compliance with standards
    - 2.2. Meaningfulness
      - organization
      - use of abbreviations
      - style
      - format
      - constrained vocabulary
    - 2.3. Readability/legibility
      - syntax
      - letter size and font
      - contrast with background
      - sufficient illumination
      - unobstructed view
      - orientation with respect to the user

        - language
    - 2.4. Highlighting
        - color coding
        - language coding
        - letter characteristics coding
        - marking coding
        - place coding
    - 2.5. Use of symbols
        - Icons
        - Graphics
        - Coding
        - Logic
- Step 3: Identify HF/S problems for signs/labeling/marking on existing systems. Problems associated with signs, labeling and marking in existing facilities will be identified and analyzed. Sources of data on problems will include interviews with users, review of accident data, and HF/S assessments of samples of existing sign/labeling/marking. The activities associated with this step are listed below.
    - 3.1. Identify information sources
    - 3.2. Prepare for data collection
        - Prepare data collection materials
        - Prepare for site visits
        - Acquire reports
    - 3.3. Acquire data on problems
        - Conduct walkthroughs
        - Conduct design evaluations
        - Review reports
    - 3.4. Analyze data
        - analyze error potential
        - analyze reports of difficulty/confusion
        - Determine non-compliance with standards
        - Identify absence of signs/ labels/markings
        - Identify erroneous signs/labels/markings
    - 3.5. Prioritize data
        - Identify relative importance of data
        - Identify highly critical operations/conditions

21.2 Identify Potential Problems with Installation

21.2.1 Identify need to determine potential problems with installations

21.2.2 Identify Lessons Learned from Baseline Systems (see Process Step 22.0)

21.2.3 Identify problems from drawings (see Process Step 15.0)

21.2.4 Identify problems from mockup walkthroughs - Mockup/model walkthroughs will be used to identify design problems and operational difficulties. The mockups will be full scale representations of the essential attributes of an installation design approach and will be constructed from cardboard or plywood for ease of construction and modification. Models

will be scaled down representations of larger areas depicting the installation concepts in existing arrangements.

21.2.5 Identify problems by comparing installation requirements and facility concepts

21.3 Identify Alternate Solutions to Problems

21.3.1 Conduct Studies to Identify Installation Concepts

- Develop HF/S engineering design requirements and concepts
  - Design concepts will be developed for user-machine and user-facility interfaces. Concepts will be developed on the basis of HF/S requirements and AE constraints as well as on the results of a HF/S assessment of a baseline predecessor system . The baseline system will comprise an existing facility in which users perform functions and tasks similar to those proposed for the new Facility, and for which HF/S problem areas can be readily identified through user interviews. Concepts will be developed through the conduct of HF/S engineering studies of four types: analytic studies, evaluation studies, experimental studies, and simulations (see Process Step 10.0) The HF/S engineering concepts to be developed will address the major user-machine and user-facility interface issues. HF/S engineering concepts will either be developed or will reflect an assessment of architectural/engineering design concepts from a HF/S engineering point of view. Specific concepts will include the following:
    - Compartmentalization concepts - room occupancy and utilization
    - Arrangements concepts - traffic patterns
    - Accommodations concepts - compartment equipment and fixtures
    - Safety concepts - concepts for hazard avoidance, guarding, or warning
    - Facility maintenance concepts - workspace and access space required
    - Equipment maintenance concepts - maintenance access
    - Environmental control concepts
    - Communications concepts
    - Supply/support concepts
- Conduct tradeoffs and select optimum concepts
  - Tradeoffs of HF/S concepts will be conducted jointly with AE representatives to select the optimum user-machine and user-facility interface concepts. Tradeoff criteria will include user requirements as well as AE constraints. Tradeoff criteria will be weighted in terms of relative importance for achieving the objectives of the facility, as well as for occupant safety and productivity considerations.
- Develop HF/S design criteria - Design criteria will be developed for each selected user-machine and user-facility interface concept. These design criteria will be derived from HF/S engineering studies and from Government and Industry standards.
- Develop alternate approaches to resolving problems
  - Alternate solutions to sign, labeling and marking problems include design solutions, training solutions and environmental solutions.

21.3.2 Identify design/redesign solutions - Design solutions include: redesign, relocation, or recoding. Design solutions also involve modifying the sign/label/marking media and/or the message.

- Select HF/S sign, labeling and marking concepts by application - This step begins with an effort to develop labeling and marking HF/S design concepts by application. Concepts will be based on alternative approaches to resolving identified problems. General approaches and special case approaches will be developed to labeling and marking by application and system. Concepts will be compared through the use of tradeoffs which will assess the adequacy of alternative design concepts in terms of selected tradeoff criteria. On the basis of the tradeoffs, optimal design, training and environmental approaches will be identified for each sign/label/marking application.
- develop HF/S design criteria and guidelines for the selected sign/ labeling and marking concepts - Design guidelines and criteria will include design requirements to implement the selected solutions by applications area. These design requirements will be derived from existing standards and handbooks. Where data are not available to support development of design guidelines and criteria, a requirement for additional research and technology development will be identified.
- Generate cost/benefit ratios for updating existing sign/label/marking schemes to the recommended concepts. Cost/benefit ratios will be developed to support the decisions to proceed with sign/labeling/marking changes. Sign/label/marking improvements having the highest payoffs at lowest cost will be recommended for initial implementation.

21.3.3 Identify Training solutions - Training solutions include alternative approaches to initial, schoolhouse training, as well as on-board training, tutoring, prompting, cueing, or otherwise helping.

21.3.4 Identify environmental solutions - Environmental solutions involve modifying the facility environment and the installation of components to support environmental control.

21.3.5 Develop installation concepts

- Objectives
  - identify and analyze user requirements for safety, security, performance, comfort and convenience
  - develop human-facility interface design approaches based on user requirements
  - develop human-facility interface design criteria and guidelines
- Scope of the effort
  - all aspects of the facility which impact user safety, security, performance, comfort and workload
  - all aspects of the human-facility interface
- Expected results
  - a standard process for integrating HF/S engineering considerations into facility design
  - design concepts and criteria for the specific facility
- Activities
  - Identify Users
    - occasional inhabiters
    - long-term inhabiters
    - maintainers/repairers
    - material handlers

    - security personnel
    - office workers
    - fire fighters
- Identify facility uses/use conditions
- Identify user functions by facility use
    - access/enter
    - configure facility
    - move to work area
    - access work area
    - configure work area
    - prepare work area
    - conduct work
    - provide security
    - inhabit facility
    - perform facility maintenance
    - perform equipment maintenance
    - access storage
    - transfer cargo
    - move to other work areas
    - communicate
    - respond to emergencies
    - verify activity completed
    - egress facility
- Identify requirements by user function
    - Information requirements - information needed to perform the function and requirements associated with the information
    - Performance requirements - specific activities and criteria for successful performance
    - Safety requirements - safety hazards associated with each function
    - Decision requirements - decisions and decision rules
    - Support requirements - support required to complete the function
    - Interface requirements - interfaces with other systems
- Conduct user task analysis
- Identify constraints
    - Identify legislative constraints
    - Identify architectural/engineering legislative constraints
    - Identify cost constraints
    - Identify builder constraints
- Develop design concepts
    - compartmentalization
    - arrangements
    - accommodations
    - safety
    - security
    - privacy
    - facility maintenance
    - equipment maintenance
    - environments

        - communications
        - supply/support
        - information handling
    - Conduct tradeoffs
    - Develop design criteria/guidelines

21.4 Identify Evaluation Requirements

21.4.1 Prepare evaluation plan - the plan will describe experimental evaluations of proposed access/egress provision improvements. The experiments will entail acquiring data on the performance of representative crew members in using existing access/egress provisions. Modifications will be made to the existing provisions as dictated by the provision improvement concept under investigation, and data will be collected on crew performance using the improved provisions. The evaluation plan will address improvement concepts to be evaluated, techniques for inexpensively implementing the concept on-board selected CG systems, and evaluation data to be collected and analyzed.

21.4.2 Identify design evaluation requirements

- Identify requirements for an HF/S design evaluations - Where the HF/S program is not concerned with developing user- machine and user-facility interface concepts, the effort will be directed to evaluating the design approaches proposed by the architect/ engineer element. The specific substeps involved in the conduct of HF/S engineering design evaluations are as follows:
- Identify System and Facility Representations
    - In this step system and facility representations will be identified for evaluation. These representations include the products of the system engineering process which are available for evaluation at each stage of development. Specific representations are as follows:
        - Descriptions of baseline facility hardware, software, information flow, procedures, and environments
        - System alternatives
        - System requirements
        - Alternate roles of the user
        - System design concepts
        - Conceptual drawings
        - Arrangement drawings
        - Subsystem design concepts
        - Static mockups
        - Detail design drawings
        - Dynamic mockups/simulations
        - Breadboards/brassboards
        - Draft documentation
        - Actual system hardware and software
        - User documentation
        - Actual system environments

21.4.3 Identify evaluation methods - The principal types of evaluation methods are: analytic methods, empirical methods, comparative measurement methods, observational/ walkthrough methods, and subjective methods.

- Analytic methods include evaluation techniques where the evaluation data are derived through analysis of the compliance of system design features with standards. Analytic methods are most applicable in the early stages of system development, where a physical representation of the system does not yet exist, and the only system representation is in the form of drawings and conceptual analyses. They are also applicable to later stages of system development where application of other evaluation methods is not feasible. An example is the application of error likelihood analysis to qualitatively estimate error potential in system operation where measurement or observation of error occurrence is not possible.
- Empirical Methods include evaluation techniques which employ applications of experimental methods. These methods can include simulations or controlled studies of specified features of system design. The distinguishing feature of these evaluations is that they involve an experimental setting.
- Comparative measurement methods involve those evaluation procedures that require measurement of some physical, functional or performance attribute of the system or system personnel and comparison of the data to standards or criteria. Typical methods include environmental effects evaluation, application of design checklists, individual/team performance measurement, and workload assessment.
- Observational/walkthrough methods include situations where the evaluation requires observation of ongoing activities, or a controlled walkthrough of operational sequences by selected test participants or by the test conductor himself, using mockups of facility areas and workspaces or the actual facility.
- Subjective methods include evaluation procedures wherein data are obtained from subject matter experts and/or actual facility users by means of interviews, surveys or questionnaires.
- Alternative methods will be identified, along with guidelines for selecting specific methods as a function of the purpose of the evaluation, specific data requirements, and the applicable phase of the materiel acquisition process.

21.4.4 Identify evaluation conditions

- Evaluation conditions are required for some evaluation methods to control the experimental setting and to ensure a high degree of fidelity between the test and the actual situation. Applicable evaluations will select evaluation conditions to be representative or worst-case. Specific types of conditions to be addressed include:
  - User characteristics including mental capability, physical dimensions, sensory/ perceptual abilities, levels of required skills such as reading level, industrial skills, and problem solving capability.
  - Features of the physical environment including noise and vibration, light level, temperature and humidity, clothing and weather.
  - Operational environment including number of activities, tempo of activities, time constraints, requirements for sustained operations, additional task requirements, constrained sequences of activities, conditions of readiness and number of users available.

- The degree of experimental control over these conditions will be a function of the required level of evaluation data reliability. The sampling plan for actually selecting conditions to be included will depend on the requirements associated with data validity

21.4.5 Identify evaluation criteria

- Evaluation criteria are the effectiveness factors against which the evaluation data are compared. These criteria can be derived from:
  - conformance to performance requirements for the system under development
  - conformance to human performance standards
  - compliance with HF/S engineering standards
  - compliance with system safety/biomedical standards
  - identified problems in the system design or in the baseline system requiring resolution through HF/S application
- The measurement of HF/S effectiveness can only be accomplished in terms of effectiveness criteria. HF/S effectiveness criteria should be explicitly derived from specific objectives of each HF/S application.
  - Criteria are of four basic types:
    - 1) normative criteria, where the emerging system is compared with the norm or baseline system on some attribute or where a problem identified in the baseline system is to be eliminated;
    - 2) performance standards or criteria associated with required levels of individual, team, system, or unit performance;
    - 3) design standards or criteria associated with aspects of the design of facilities, hardware, software, environments, information flow, or procedures; and
    - 4) cost criteria or cost thresholds.
  - Examples of the types of criteria which should be established are as follows:
    - Normative criteria
      - error rates are reduced as compared with the baseline facility
      - system availability is improved as compared with the baseline facility
      - mean time to repair is improved as compared with the baseline facility
      - accident rates are reduced as compared with the baseline facility
      - the number and severity of hazards is reduced as compared with the baseline facility
    - Performance standards
      - required personnel are available in required numbers.
      - formal training will require no more than ___ days, weeks, or months.
      - in the training program, special attention is devoted to refreshing critical perishable skills
      - no special skills are required
    - Design standards
      - Design aspects of the system are in conformance with applicable standards
      - User-equipment and user-facility interface design is in compliance with accepted HF/S engineering standards
    - Cost criteria
      - total life cycle costs for the emerging system are reduced as

compared with the baseline facility
- costs of redesigning to eliminate design flaws is reduced as compared with the baseline facility
- the impact of human errors and accidents is reduced as compared with the baseline facility

- No evaluation of HF/S effectiveness can be undertaken without a clear statement of the evaluation criteria to be employed in the evaluation.

21.4.6 Identify evaluation measures - by type of measure

- HF/S engineering evaluation measures are a direct function of the selected evaluation methods and the evaluation data requirements. Representative measures include:
  - individual and crew performance measures
    - probability of success
    - elimination of performance problems identified in the baseline facility
  - design for operability
    - operator error rates
    - special skills required of operational personnel
    - measures of workload and workload distribution
    - measures of communications effectiveness
    - elimination of operability problems identified in the baseline facility
  - design for maintainability
    - time to repair
    - false diagnosis rate
    - number and severity of equipment failures resulting from human error
    - maintainer error rates
    - maintainer skill requirements
    - elimination of maintainability problems identified in the baseline facility
  - personnel availability/utilization
    - personnel mental categories required
    - numbers of personnel required to man the system/unit
    - elimination of manning and workload problems identified in baseline systems
  - personnel training
    - training effectiveness measures
    - measures to assess effectiveness of training to refresh perishable skills
    - measures to assess effectiveness of onboard, organic or embedded training
    - elimination of training problems identified in baseline systems
  - personnel survivability
    - measures of degree of protection provided
    - measures of performance impairment wearing protective equipment
    - time and errors associated with responding to alarms and warning signals
    - accident rates
    - elimination of survivability problems identified in baseline systems
  - supportability
    - time to resupply units and systems
    - measures of accessibility, readability and usability of user documentation

        - elimination of supportability problems identified in baseline systems
    - facility or enclosure habitability
        - measures of sustained performance in all environments
        - incidence of health hazards
        - elimination of habitability problems identified in baseline systems
    - system development costs
        - cost of redesign to eliminate design flaws
        - training development costs
        - training system development costs
        - elimination of high development cost problems identified in baseline systems
    - system overhead and life cycle costs
        - cost of manning the system
        - personnel costs
        - overall training costs
        - costs associated with human errors
        - elimination of high system overhead and life cycle cost problems in baseline systems
- Identify Evaluation measures by feature to be evaluated
    - Compartmentalization
        - Room design
            - number of rooms
                - ratio of number of rooms to total space
                - room function
                - user activities
                - room identification
                - compatibility of shared functions
                - room occupancy - normal
                - numbers
                - room occupancy - occasional
                - numbers
                - room occupancy - maximum
                - numbers
                - room size and shape
                - adequacy of size for occupancy
                - adequacy of shape for functions
                - room location with respect to
                - accesses/egresses
                - resources
            - Passageways
                - passageway/corridor size
                    - dimensions
                    - obstructions
                    - corridor interface with rooms
                    - door opening
                    - space for door opening
                    - obstructions in the entryway
            - General arrangements

    - Between rooms
    - functional relationships among rooms
        - expected problems due to traffic patterns
        - consistency with convention
        - room location with respect to other rooms
        - minimization of travel time
        - noise interference problems
        - traffic interference problems
        - electrical interference problems
        - Areas within rooms
        - standard arrangement - equipment in areas
        - convention
        - consistency across rooms
        - provisions for modifying arrangements
        - difficulty in modifying arrangements
        - time to modify
        - provisions for individualized arrangements
        - degree to which the design fosters individualized arrangements
        - adequacy of procedures for individualizing the arrangements
        - arrangement of areas
        - minimization of travel time
- Levels
    - arrangement of levels
        - distances between levels
        - identification of levels in the elevator
        - un-ambiguity of signals
        - level accesses
        - time to access levels
        - controlled access
- Exits and stairs
    - location/arrangement of exits
        - time to access
        - signs and markings
        - location/arrangement of emergency exit
        - time to access
        - signs and markings
        - location and arrangement of stairs
        - time to access
        - signs and markings
        - stair/step dimensions
        - tread width
        - step height
        - handholds
        - location
        - clearance
- Traffic

- traffic patterns
  - design factors affecting the traffic patterns
  - consistency of traffic loads
  - temporal considerations

- Accommodations - Fixtures
  - light fixture location
    - standard - consistent
    - accessible
    - light pattern
    - light levels
    - light control
    - control type
    - control location
    - HVAC outlet location
    - standard - consistent
    - accessible
    - effectiveness
    - HVAC control
    - control type
    - control location
    - control access
    - electrical outlet location
    - standard - consistent
    - accessible
    - telephone jack location
    - standard - consistent
    - accessible
    - television hookup location
    - standard - consistent
    - accessible
    - modem hookup location
    - standard - consistent
    - accessible

- Office automation
  - accommodations for office automation
    - electrical accommodations
    - network provisions
  - Doors
    - area door location
      - consistency of location
      - facility door location
      - consistency of location
      - area door size and shape
      - clearance
      - facility door size and shape
      - clearance
  - Windows
    - window location

        - consistency
        - opening procedures
        - location WRT sunlight
        - window size and shape
        - light levels
- Storage
    - facility storage space location & design
        - arrangements
        - area storage space location & design
        - arrangements
        - storage space identification
        - signs and markings
- Furnishings
    - furnishings
        - impact on performance
        - impact on comfort
        - impact on safety
        - decor
        - consistency
        - impact on performance
        - aesthetics
        - impact on performance
- Special accommodations
    - accommodations for the handicapped
        - wheel chair access
        - provisions for the blind
        - provisions for the elderly
        - accommodations for socialization
        - noise control
        - accommodations for meetings
        - meeting space arrangements
        - accommodations for entertainment
- Signs, markings and labels
    - signs
        - readability
        - location
        - labels and markings
        - location
        - understandability
- Safety/security/survivability
    - Alarms
        - perceptibility
        - distinguishability
        - loudness
- Entry/exits
    - locks
        - operation
        - barriers

        - location
        - operation
        - emergency exits
        - location
        - marking
- Fire fighting
    - fire fighting systems
        - sprinklers
        - extinguishers
        - fire alarms
        - fire phones
        - location of fire alarms/phones
        - frequency
        - location of phones
        - location of alarms
- Hazards
    - protection from hazards
        - guards
        - interlocks
        - markings
- Surveillance
    - surveillance systems - audio
        - sensitivity
        - coverage
        - surveillance systems - visual
        - field of view
        - direction of view
- Lighting for security
    - lighting
        - levels
        - patterns
        - spectral composition
        - light locations
        - number
        - arrangement
- Safety features
    - warnings - signs
        - readability
        - location
        - safety railings
        - marking
        - dimensions
        - safety guards/barricades
        - marking
        - dimensions
        - non-slip surfaces
        - adequacy when wet
        - provisions for first aid

        - locations
        - marking
    - Security features
        - links to security
            - alarms
            - telephone
            - emergency power and lighting
            - operation
            - after-hours access
            - key operation
    - Facility maintenance access
        - access for refurbishment
            - clearances
            - access size
            - access safety
            - access visibility
            - access for repair
            - clearances
            - access size
            - access safety
            - access visibility
            - access for cleaning
            - clearances
            - access size
            - access safety
            - access visibility
            - access for troubleshooting
            - clearances
            - access size
            - access safety
            - access visibility
            - access for inspection
            - clearances
            - access size
            - access safety
            - access visibility
    - Maintenance space
        - equipment layout space
            - adequacy of space
            - cargo handling
            - load transport assist
            - maintenance workspace
            - visibility
            - obstructions
            - tool access
    - Maintenance procedures
        - procedures
            - consistency

        - accessibility
        - readability
    - Maintenance fixtures
        - fixtures to facilitate maintenance
            - power
            - test points
            - service points
            - lighting
            - storage for maintenance
            - tools storage
            - spares storage
    - Equipment maintenance - provisions
        - provisions for fault detection
            - test provisions
            - provisions for fault isolation
            - test provisions
    - Equipment maintenance - access
        - access for preventive maintenance
            - clearances
            - access size
            - access safety
            - access visibility
            - access for removal/replacement
            - clearances
            - access size
            - access safety
            - access visibility
    - Equipment maintenance facilities
        - repair facilities
            - shop tools
            - test/service point location/arrangement
            - location
            - marking
            - cargo/component handling
            - provisions for transport
    - Environment - Vision/visibility
        - lighting and control - facility
            - illumination levels
            - illumination coverage
            - illumination uniformity
            - adequacy of controls
            - lighting and control - area
            - illumination levels
            - illumination coverage
            - illumination uniformity
            - adequacy of controls
            - glare control
            - surfaces

- Environment - Noise and vibration
  - noise control
    - adequacy of noise absorption
    - adequacy of noise attenuation
    - vibration control
    - adequacy of vibration attenuation
- Environment - Space
  - free volume - space
    - obstructions
    - amount of free volume
- Environment - Temperature and humidity
  - temperature
    - limits
    - stability
    - uniformity at different locations
    - temperature control
    - precision
    - location
    - humidity control
    - precision
    - location
- Environment - Weather
  - countermeasures
    - adequacy of covers
    - adequacy of non-slip surfaces in ice
- Communications - aided
  - internal aided communications
    - intelligibility
    - operation
    - maintenance
    - location
    - external aided communications
    - intelligibility
    - operation
    - maintenance
    - location
- Communications - Unaided
  - unaided voice communications
    - noise levels
    - face to face
    - distances
- Supply/support - Storage
  - ready storage area location
    - with respect to cargo handling
    - ready storage access
    - markings
    - identification of stored item location
    - access dimensions

        - deep storage location
        - with respect to cargo handling
        - deep storage access
        - markings
        - identification of stored item location
        - access dimensions
        - storage area size and shape
        - activities required inside the space
        - adequacy of size & shape
        - storage area arrangement
        - arrangement for ease of access
- Cargo
    - cargo transfer
        - load handling
        - load monitoring during transfer
        - cargo handling
        - aided handling
        - loading dock accommodations
        - ramp dimensions
        - lighting
        - inventory control
        - information system
        - data entry
- Elevators
    - location of elevators/lifts
        - with respect to corridors/passageways
        - with respect to rooms/spaces
        - with respect to cargo handlers
        - size of elevators/lifts
        - dimensions
        - Specific room/area considerations
- Facility exterior
    - identification
        - sign readability
        - illumination
        - lighting of walkways
        - lighting of signs
        - weather countermeasures
        - provision of cover over walkways
        - snow removal provisions
        - safety
        - non-slip surfaces
- HVAC/machinery
    - signs and markings
        - sign readability
        - marking visibility
        - conventions
        - workspace

        - lighting
        - clearances
        - access
    - Corridors/passageways
        - signs and markings
            - sign readability
            - marking visibility
            - conventions
            - lighting
            - levels
            - security
            - call for help provisions
            - after hours security
            - distances from/to elevators
            - maximum distances
    - Rest rooms
        - standard locations
            - consistency of location
            - safety
            - non-slip surfaces
            - guarded hazards
            - cleaning
            - scheduled frequency
            - design to facilitate cleaning
            - restock of tissues/soap/etc.
            - ease of restock
            - environment
            - air circulation

21.4.7 Identify Data Acquisition and Recording Techniques

- Designation of techniques for data acquisition and recording will depend on the data to be acquired, the evaluation criteria, the types of measures, and the characteristics of data quantity, quality, reliability, validity and affordability. Techniques to acquire and record data on measures will be developed for the HF/S evaluation conducted for the baseline system.

21.4.8 Prepare Evaluation Materials

- Evaluation materials include software to support the application of HF/S measures. These materials can include simulation exercises and software, mockups, evaluation media, test software, and special documentation such as checklists and questionnaires.
- Identify Evaluation Procedures
- Evaluation procedures to be developed include:
    - Test set-up procedures
    - Test participant selection and training procedures
    - Test participant test procedures

- Test conductor monitoring procedures
- Test conductor test control procedures
- Data analysis procedures

21.5 Assess/Prepare Installation Criteria

21.5.1 Review results of evaluations of installation concepts

21.5.2 Assemble Candidate Installation criteria

21.5.3 Select Installation Criteria